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VIRGINIA SALTWATER RECREATIONAL FISHING DEVELOPMENT FUND
SUMMARY PROJECT APPLICATION*

NAME AND ADDRESS OF APPLICANT:	PROJECT LEADER (name, phone, e-mail):
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PRIORITY AREA OF CONCERN:	**PROJECT LOCATION:**
Research and Data Collection	Rappahannock River (2 locations)

DESCRIPTIVE TITLE OF PROJECT:

Understanding the impacts of mycobacterial disease on striped bass: when and where does mortality occur in the Rappahannock River?

PROJECT SUMMARY:

Recent research has shown that mycobacterial skin disease in striped bass is a slow acting (2-3 year) disease that reduces growth and increases mortality. The data suggest there is a seasonal effect of the disease but this has not been established. Also, parasite data suggest resident striped bass upstream (river mile 45) may be a distinct subpopulation from resident fish at the mouth. The proposed work is to tag bass with and without signs of disease in the spring and fall so that summer growth, disease progression and disease-associated mortality can be compared to that in winter. Tagging and parasite data will be used to study movements and mixing of bass in the river. The goal is to understand when and where the disease is affecting the bass.

EXPECTED BENEFITS:

To devise management strategies for dealing with mycobacteriosis we need to know where and under what environmental conditions the disease flourishes. One theory is that hypoxia reduces the amount of thermal refugia (areas of cool water that allow bass to escape thermal stress in summer), thus forcing bass to stay in warm water where they are more susceptible to disease. If this is true, then improving water quality would be an appropriate response. Otherwise, improving water quality, while generally a good idea, will not address the disease problem. Thus, it is important to determine if body growth, disease progression and disease associated mortality vary by season with impacts being highest in the warm part of the year. Likewise, it is important to understand the movements of bass in the river to see if there are separate contingents that may vary in susceptibility to the disease based on location.

COSTS:

VMRC Funding:	50,535
Recipient Funding:	25,388
Total Costs:	**75,923**

Detailed budget must be included with proposal.

Updated 11/12/08

*This form alone does not constitute a complete application, see application instructions or contact Sonya Davis at 757-247-8155 or sonya.davis@mrc.virginia.gov

BUDGET

VMRC MYCO 2009

	VMRC	VIMS	TOTAL
Personnel			
Hoenig, PI 1.0 mon	5,046	5,046	10,092
Vogelbein, 1.0 mon	4,225	4,225	8,450
Field support, 1.5 mon	5,349		5,349
Lab support, 1.5 mon	6,000		6,000
Field liaison	2,500		2,500
Fringe, 35% salaries	7,408	3,245	10,653
Supplies			
Field supplies - $1,000 tags; field supplies	1,500		1,500
Lab supplies	5,000		5,000
Travel - trucks for field	1,000		1,000
Vessel	1,500		1,500
Tag rewards	1,500		1,500
Facilities & Administrative Costs	9,507	12,872	22,379
Total	50,535	25,388	75,923

Proposal Submission to

Virginia Marine Resources Commission

By

THE VIRGINIA INSTITUTE OF MARINE SCIENCE
COLLEGE OF WILLIAM AND MARY

Understanding the impacts of mycobacterial disease on striped bass: when and where does mortality occur in the Rappahannock River?

John M. Hoenig
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and Advisory Services

April 15, 2009

Understanding the impacts of mycobacterial disease on striped bass: when and where does mortality occur in the Rappahannock River?

Introduction

The problem and recent advances in our understanding

Mycobacteriosis, a chronic bacterial disease, was first documented in wild striped bass in the Chesapeake Bay system in the late 1990s (Vogelbein et al. 1999). Subsequent bacteriological studies at VIMS characterized and named the etiologic agents (Rhodes et al. 2002, 2003, 2004). Since then, the prevalence of the disease has risen so that in some places, notably in the Rappahannock River, virtually all resident fish become infected with the disease (Vogelbein and Hoenig, unpublished observations). Although mycobacteriosis is a chronic disease, in aquaculture systems the appearance of mycobacterial skin disease is thought to represent the terminal phase of the disease with death imminent. It was not known, however, what impacts mycobacterial disease might have on wild striped bass.

Recent work, funded in part by the Virginia Marine Resource Commission through the Recreational Fisheries Advisory Board, has now shed considerable light on the impacts of the disease. Fish with and without external signs of the disease have been captured, photographed, tagged and released. Fishers are offered a $5 reward for the return of a tag and a $20 reward for the return of the fish carcass. The State of Maryland is participating in this cooperative study so that recaptured fish taken in Maryland are retrieved by Maryland personnel and fish recaptured in Virginia are retrieved by VIMS personnel. To facilitate this research, the Virginia Marine Resources Commission, the Potomac River Commission and the Maryland Department of Natural Resources have issued rules to allow fishers to possess fish with the special green-colored tags used in this study regardless of season, bag limit, or size of the fish.

The results to date are imprecise due to low sample sizes but nonetheless clearly demonstrate the following:

- It takes around 350 - 450 days for fish to progress from the first identifiable stage of the disease (having small brown dots known as pigmented foci and small ulcerous skin lesions) to the second stage of the disease (moderate external signs of disease) and around 400 - 500 days to progress from the second stage to the third (severe external signs of disease). The disease is indeed chronic. (Figures 1a and 1b)

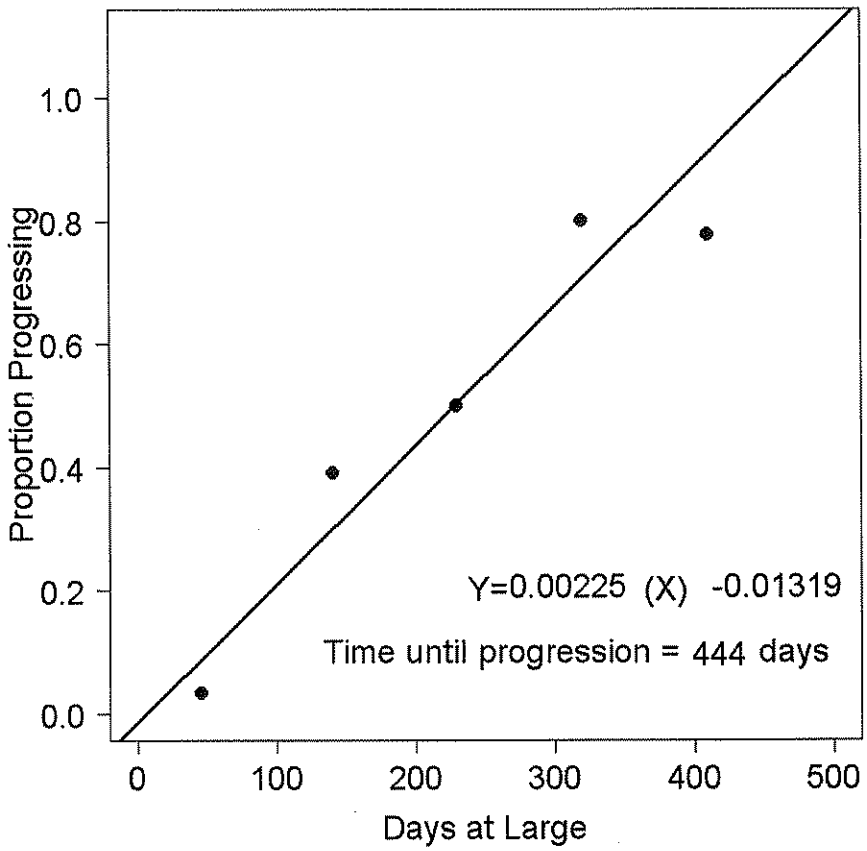

Figure 1a. Proportion of fish advancing from disease category 1 to disease category as a function of time. The regression line indicates that all fish will have progressed by the time they have been at liberty for 444 days, thus providing an estimate of the duration of disease category 1.

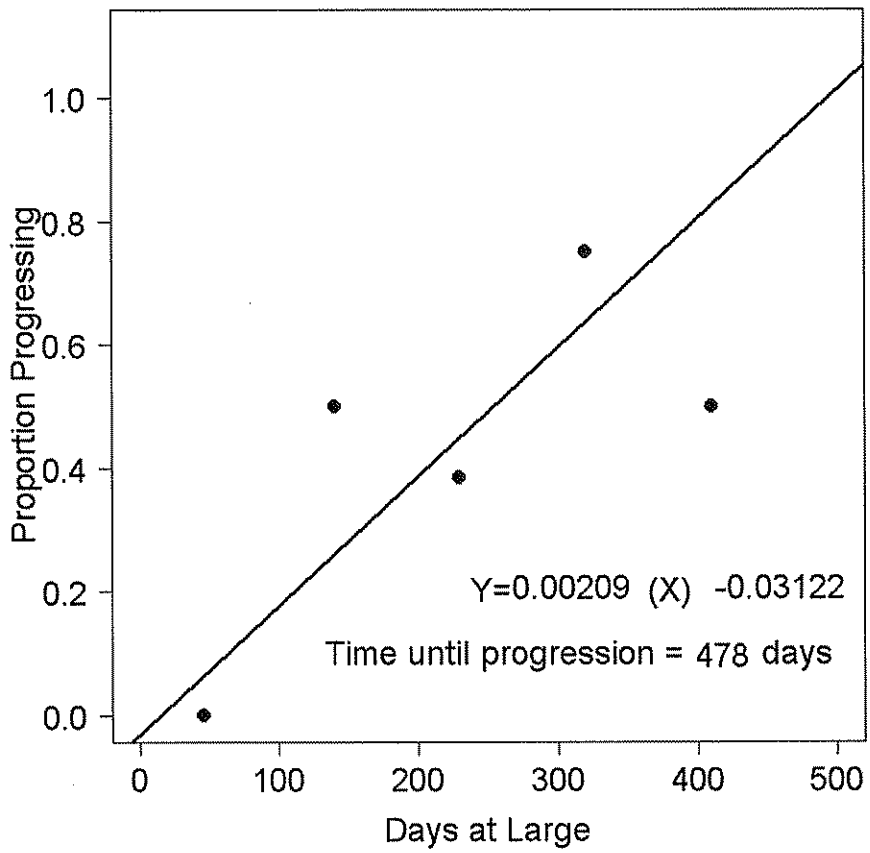

Figure 1b. Proportion of fish advancing from disease category 2 to disease category 3 as a function of time. The regression line indicates that all fish will have progressed by the time they have been at liberty for 478 days, thus providing an estimate of the duration of disease category 2. Method of Munro (1983).

- Growth of fish in stages 2 and 3 appears to be about 40% slower than fish without signs of the disease or with early signs (stage 1). (Figure 2)

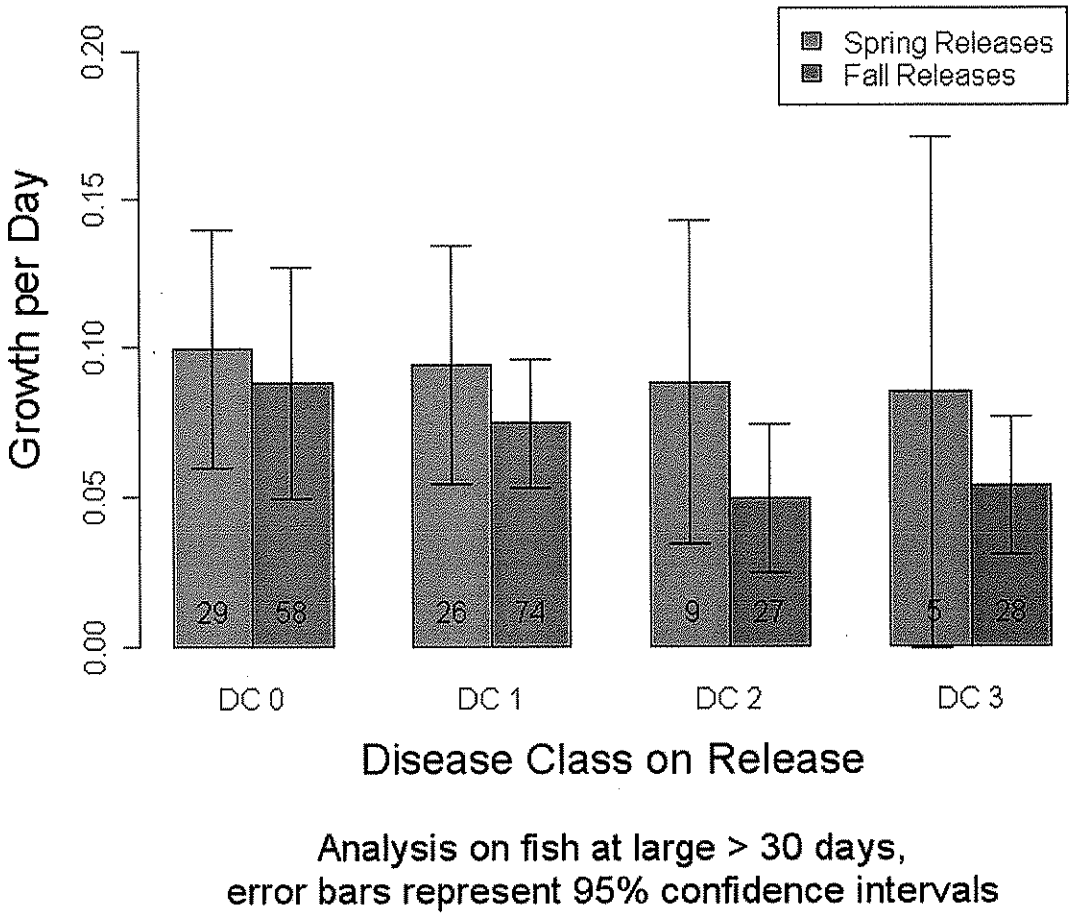

Figure 2. Comparison of growth of striped bass in different disease condition categories. DC0 represents fish without outward signs of mycobacterial disease; DC!, DC2 and DC3 represent increasing severe cases of the disease. Note that a decline in growth across disease categories is clear in the fall tagging data but is not statistically significant in the spring data. The sample sizes for spring tagged fish are low.

- Fish in disease stages 2 and 3 appear to have approximately half the survival rate of fish without external signs of the disease; fish in stage 1 appear to have 80 - 90% of the survival rate of fish without signs of the disease, but this latter result is not statistically significant at this point. (Figure 3).

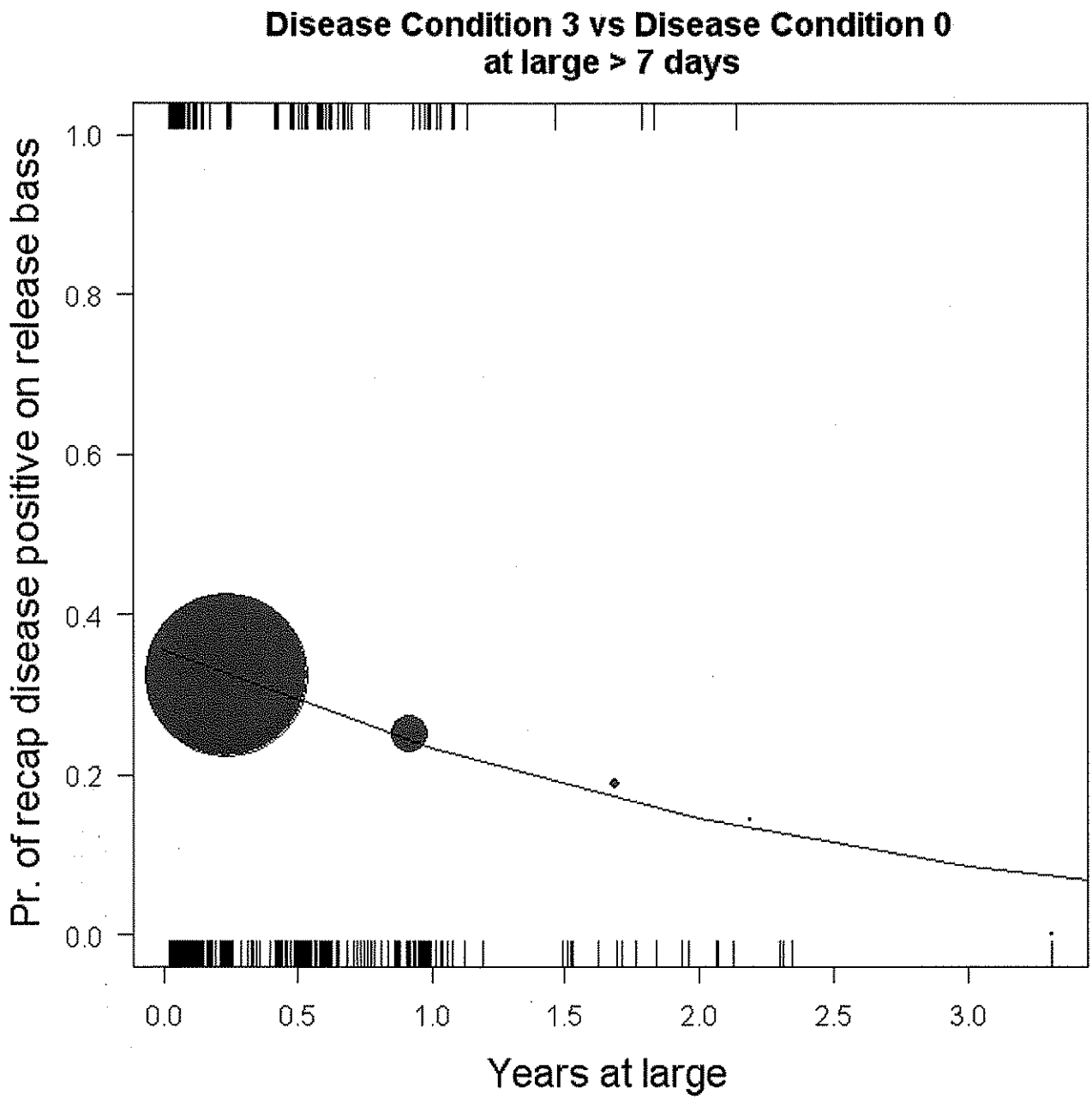

Figure 3. Logistic regression showing relative survival of striped bass in disease condition 3 (severely diseased) versus disease condition 0 (no signs of the disease). As the time at liberty increases, the chances that a recaptured fish will have been tagged in disease condition 3 (as apposed to disease condition 0) declines because those tagged in condition 3 are not surviving as well as those tagged in condition 0. Estimated relative survival = 0.55, p = .024. Symbol size is proportional to number of recaptures. Note that there is one data point with time at liberty between 2.0 and 3.0 and another at time of liberty > 3.0. Method of Hueter et al. (2006).

Our findings that elevated levels of natural mortality are associated with mycobacterial disease are consistent with results from a model of prevalence-at-age (Gauthier et al. 2008) and findings by Jiang et al. (2007) that total mortality rate rose at about the same time as mycobacteriosis prevalence increased.

NEED

Information on the ecology of mycobacterial disease is needed in order to formulate effective management plans for dealing with the problem. We need to know when and where the disease is affecting the bass and what conditions enable the disease to thrive.

If resident striped bass in the Rappahannock River move widely throughout the river then the prevalence of the disease should be uniform over space making it difficult to identify conditions or habitats that allow the disease to flourish. Our studies so far indicate that this is indeed the case. (John the disease is uniform between upper and lower Rapp) (Resident striped bass are defined by the Atlantic States Marine Fisheries Commission's striped bass committee as all striped bass found in the river in the fall and all male striped bass under 28 inches found in the river in the spring.) However, recent preliminary observations cast doubt on the assumption that resident striped bass are wide ranging in the Rappahannock River. The fish upstream (river mile 45) have a high prevalence of infection with larval trematodes (metacercaria in the spleen) whereas fish at the mouth of the river have the reverse situation (low trematode prevalence). This suggests a clear separation between the fish from the two sites. Parasites have a long history of use as biological tags to study stock separation and migratory movements in fishes (MacKenzie and Abaunza. 1998, MacKenzie, K. 2002, MacKenzie et al., 2007).

Fish movements in the rivers are of importance because they may shed light on where and when disease impacts occur. One theory is that elevated summer water temperatures are stressful for striped bass, and bass attempt to overcome this problem by seeking shelter in pockets of cool water (thermal refugia). However, today large portions of the Bay, including the mouth and other portions of the Rappahannock River, have cool water that is anoxic or hypoxic. Thus, the loss of thermally suitable habitat may be forcing bass to remain in warm water making them more susceptible to disease. Disease impacts may thus be localized (although affected fish may move and mingle with fish from other areas at certain times of the year). If this theory is true, then improvements in water quality may reduce disease impacts.

If the thermal stress hypothesis is significant, then we would expect that effects of the disease would manifest themselves especially in the warm part of the year. Indeed, there are some hints in the existing data that there is a seasonal component to disease impacts based on a comparison of results from extensive fall tagging and limited spring tagging. However, the results are not statistically significant.

OBJECTIVE

We propose to investigate mycobacterial disease ecology by looking at the seasonal and spatial impacts of the disease. The seasonal impacts will be addressed by continuing and increasing the spring (April – May) tagging efforts and bolstering the fall (September – November) tagging. Currently, spring tagging for disease research is unfunded and is being conducted on an opportunistic basis. The result has been small sample sizes (0 – 600 fish tagged per spring since 2005) that preclude drawing inferences about the seasonal aspects of the disease. We seek to compare body growth rates, disease progression rates and relative survival of diseased fish and fish without signs of the disease over the warm half and the cold half of the year. The spatial aspects will be addressed by analyzing 21 years of tagging data from the Rappahannock River to determine the degree to which resident fish move in the river and determine the seasonality of movements at each age. (Age can be determined because scale samples have been collected from each tagged fish.) The tagging data have previously been used to estimate mortality rates, fidelity of migrating bass to their natal stream, and to examine large scale movements; they have not been analyzed to characterize localized, seasonal movements. We will also compare the prevalence of striped bass infections with larval trematodes at the mouth of the river and upstream in both the spring and fall and attempt to identify the trematode. We seek to confirm or reject the idea that resident striped bass upstream and

at the mouth of the river show little mingling at least at certain times of the year and to determine if there are seasonal patterns to the movement. We also wish to determine if disease status affects behavior of striped bass by altering movement patterns. It is possible that diseased fish have reduced swimming capacity and exhibit less movement.

EXPECTED RESULTS AND BENEFITS

To devise management strategies for dealing with mycobacteriosis we need to know where and under what conditions the disease flourishes. If the hypothesis that limited summer thermal refugia causes striped bass to be susceptible to disease is true, then improving water quality would be an appropriate (but costly) response. Otherwise, improving water quality, while generally a good idea, will not address the disease problem. Thus, it is important to determine if disease impacts are higher in summer than in the cool part of the year. We will evaluate this by estimating body growth rates, disease progression rates and disease associated mortality by season to see if impacts are highest in the warm part of the year. Previous work has demonstrated the feasibility of this approach. Likewise, it is important to understand the movements of bass in the river to see if there are separate contingents that may vary in susceptibility to the disease based on location.

The benefits of understanding the role of environmental conditions on the mediation of disease impacts accrue to all fishers, sport and commercial, through improved fishery and environmental management plans.

APPROACH

Fish for tagging will be obtained upstream (ca. river mile 45) and at the mouth of the Rappahannock River (river miles 0 to 3) from commercial pound nets. The same protocol that has been used in the cooperative VIMS – Maryland Department of Natural Resources study in the fall will be used here. (Funds are needed to do spring tagging and to bolster fall tagging. For the spring tagging, the target is to tag 500 fish; for the fall, the target is to augment the number tagged by 250.) Fish are held in live cars (floating net pockets) in the river until they can be processed. A scale sample is taken from each fish, and the fish is measured, photographed (to document disease status), tagged with a special green Floy anchor tag with a message indicating the reward and contact information, and released at the capture site. Fish recaptured by fishers can be reported by calling an 800 (toll free) telephone number manned by VIMS personnel seven days a week. (The phone number appears on the tag.) Posters, flyers and other publicity materials have been distributed for 3 years explaining the significance of the green tags so cooperation of fishers is now excellent. Such publicity efforts will continue.

Disease progression rates, body growth rates, and relative survival rates (ratio of survival of diseased fish to fish showing no signs of the disease) will be computed for spring tagged fish using the same methods as used recently for fall tagged fish. (Progression rates are estimated using the methods of Munro (1983) and Millar and Hoenig (1997); relative survival rate is estimated using a logistic model, as described by Hueter et al. (2006).) This will allow a test of the hypothesis that the season has no affect on disease impacts.

Tissue squashes will be taken from a sample of fish spleens in the fall and the spring at both the mouth and upriver locations and, if larval trematodes (metacercaria) are present, they will be identified to the lowest possible taxonomic group using standard techniques. Trematode identification involves feeding an infected tissue sample to chicks and then sacrificing the chicks after several days to look for adult worms. Identification of the species of trematode is important

because trematodes have very specific life cycles and the distribution and habitat of the hosts can be an important clue to where the striped bass has been.

The historical and current tagging data will be analyzed to determine movement patterns as follows. Striped bass have been tagged annually in the Rappahannock River since the fall of 1987. Fish have been tagged both upstream and at the mouth of the river in both the spring and the fall. Scale samples for age determination have been taken as well as measurements of the length of the fish. In the most recent 3 years, mycobacterial disease status has also been recorded for some fish. Only resident fish, defined by their age, sex, and size, will be analyzed. Analyses will be conducted on an age-specific basis. Data will be sorted by age of fish, season of tagging and time at liberty so that movements can be characterized for each combination of location of tagging and time at liberty. In particular, we will focus on movements of fish at liberty for one season (spring to fall or fall to spring), one year (spring to spring or fall to fall) and fish at liberty for x years or x years plus one season, where $x = 1, 2, 3, \ldots$ For the recent data, we will also examine whether movements of fish showing advanced stages of the disease differs from that of fish showing no or mild signs of the disease.

This work will be accomplished by the existing staff of the striped bass assessment and monitoring project at the Virginia Institute of Marine Science with the help of part-time, temporary student help.

LOCATION

Field work will take place in the Rappahannock River at the mouth (river miles 0 to 3) and upstream (river miles 45 to 47). Laboratory work and data processing will take place at the Virginia Institute of Marine Science in Gloucester Point.

Literature Cited

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